AERIAL MOOSE SURVEY
on and around
KANUTI NATIONAL WILDLIFE REFUGE
November, 2013

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and

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DATA SUMMARY

Survey Dates:	12- 18 November (Intensive survey only)
Total area covered by survey:	Kanuti National Wildlife Refuge (hereafter, Refuge) Survey Area: 2,715 mi^2 (7,029 km^2); Total Survey Area: 3,736 mi^2 (9676 km^2)
Total Number sample units	Refuge Survey Area: 508; Total Survey Area: 701
Number of sample units surveyed:	Refuge Survey Area: 105; Total Survey Area: 129
Total moose observed:	Refuge Survey Area: 259 moose (130 cows, 95 bulls, and 34 calves); Total Survey Area: 289 moose (145 cows, 105 bulls, 39 calves)
November population estimate:	Refuge Survey Area: 551 moose (90% confidence interval = 410 - 693) comprised of 283 cows, 183 bulls, and 108 calves*; Total Survey Area: 768 moose (90% confidence interval = 589 – 947) comprised of 387 cows, 257 bulls, 144 calves*. *Subtotals by class do not equal the total population because of accumulated error associated with each estimate.
Estimated total density:	Refuge Survey Area: 0.20 moose/mi^2 (0.08 moose/km^2); Total Survey Area: 0.21 moose/mi^2 (0.08 moose/km^2)
Estimated ratios:	Refuge survey area: 36 calves:100 cows, 11 yearling bulls:100 cows, 37 large bulls:100 cows, 65 total bulls:100 cows; Total Survey Area: 35 calves:100 cows, 11 yearling bulls:100 cows, 40 large bulls:100 cows, 67 total bulls:100 cows

INTRODUCTION

The Kanuti National Wildlife Refuge (hereafter, Refuge), the Alaska Department of Fish and Game (ADF&G) and the Bureau of Land Management cooperatively conducted a moose (*Alces alces*) population survey 12 - 18 November 2013 on, and around, the Refuge. Moose surveys were conducted on the Refuge since 1989 using two different methods. The Gasaway method (Gasaway et al. 1986) was employed in 1989 and 1993 and the Geo-Spatial Population Estimator (GSPE) (Ver Hoef 2002 and 2008, Kellie and Delong 2006) was used in 1999, 2004, 2005, 2007, 2008, 2010 and 2011. GSPE surveys done since 1999 have shown that the moose density in the survey area remains low, and persists at a low-density dynamic equilibrium (Gasaway et al. 1992).

Moose are an important subsistence resource for the residents of four villages which are located near the survey area: Bettles, Evansville, Alatna, and Allakaket. Estimated average harvest of moose in these villages, as measured during household surveys from 1997 through 2002, was 37 moose per year (Brown et al. 2004). Non-local hunting pressure is light in the area, both because most of the Refuge is closed to moose hunting by non-local hunters, and because the remaining open hunting areas are difficult and expensive to access. The low moose density in the area is a further disincentive for non-rural hunters. Nonetheless, the low moose density and local resident perception that subsistence harvest is declining have led to a local resident concern about allocation of moose between local and non-local hunters. Other issues related to moose management in the area are the effect of predation on the moose population and distribution of moose to areas where they are accessible to human harvest.

The objectives of the 2013 moose survey were to: 1) continue monitoring the moose population on the Refuge using the GSPE method for management decision purposes, 2) maintain the precision of the population estimate by surveying a larger number of sample units than just the Refuge, and 3) add additional data to the Bayesian regression analysis of the moose population estimates for the Refuge.

STUDY AREA

The survey occurred over a part of Game Management Unit 24B in north-central Alaska (Figure 1). Topography in the survey area is relatively flat, with rolling hills around the periphery of the Refuge. Vegetation types include black and white spruce (*Picea mariana* and *P. glauca*, respectively) forest, black spruce woodland, paper birch (*Betula papyrifera*) forest, mixed spruce/birch forest, tall and low shrub communities, tussock tundra dominated by tussock cottongrass (*Eriophorum vaginatum*), and riparian and wetland areas dominated by willows (*Salix* spp.) and other deciduous vegetation. The types and ages of plant communities are strongly influenced by fire history; more than 70% of the Refuge burned since 1940.

Although the survey was conducted seamlessly, the survey area was treated as two entities for analysis: the Refuge Survey Area (2,714 mi^2 [7,029 km^2]) and the Total Survey Area (3,736 mi^2 [9676 km^2]). The 2013 Refuge Survey Area boundaries and sample units were the same as used since 1999, which allowed comparisons with those surveys. The Total Survey Area included both the Refuge Survey Area and additional survey units of the lower Alatna River drainage west of the Refuge.

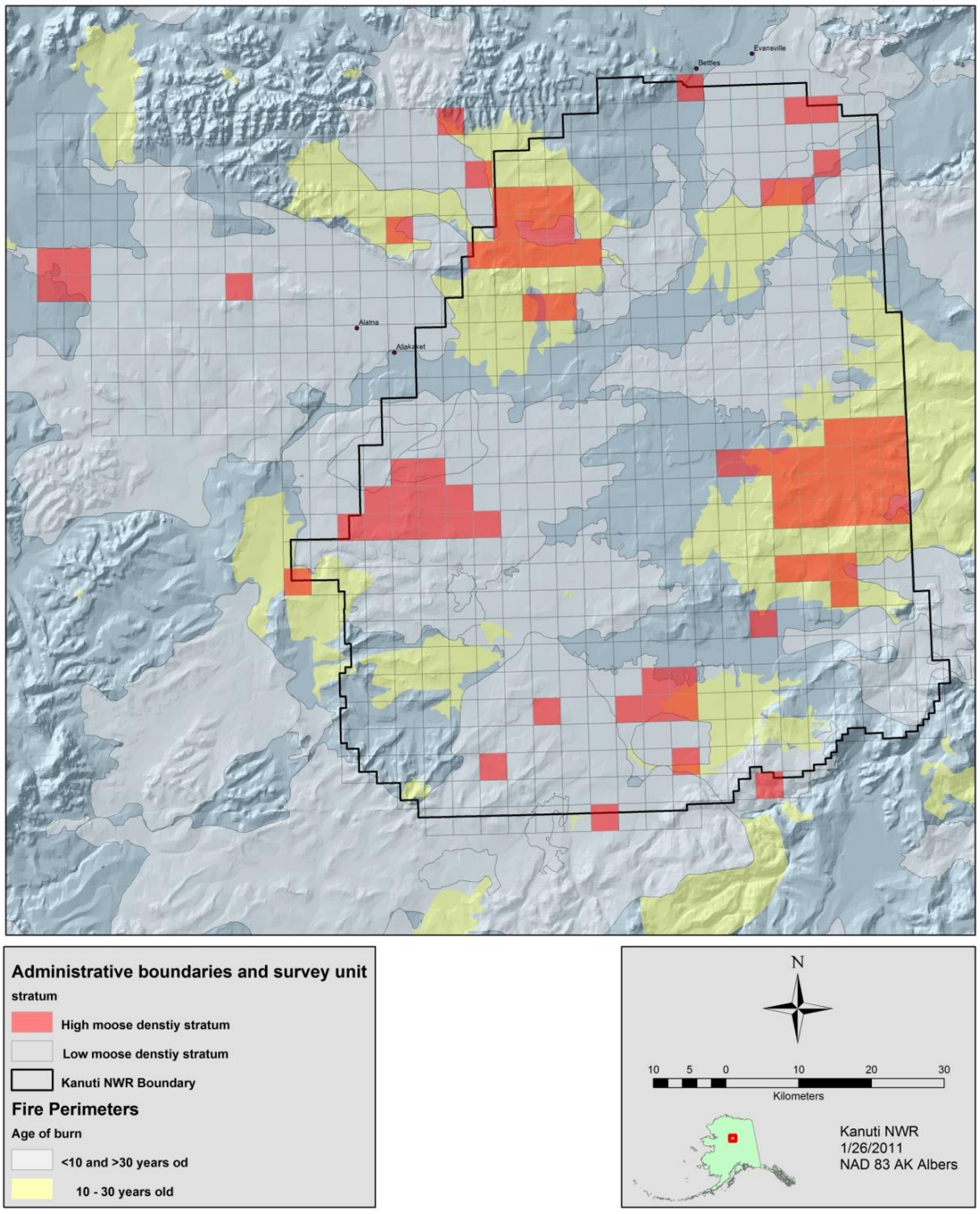


Figure 1. Survey units for a moose survey conducted in November, 2013, Game Management Unit 24B, Alaska. Kanuti National Wildlife Refuge boundary, fire perimeters for burns of two different age allocations (burns 10 – 30 years old are preferred by moose), and moose density stratum are displayed.

METHODS

We conducted the moose population survey using the GSPE method, a modification of a technique initially developed by Gasaway et al. (1986) that was used on the Refuge in 1989 and 1993. The GSPE method is widely used in Alaska, which allows comparison

between survey areas. Methods for the GSPE method are discussed in detail in Kellie and DeLong (2006) but will be summarized in this report.

The survey area was delineated using a Geographical Information System (GIS) layer developed by ADF&G that divides the state into a grid of sample units that measure 2 minutes latitude by 5 minutes longitude on a side. Sample units in our survey area averaged about 5.3 mi^2 (13.7 km^2) in size. The area includes 508 sample units that were surveyed on the Refuge (aka Refuge Survey Area) from 1999 to 2010. In addition, we added 193 more sample units in 2011 on State, Bureau of Land Management administered lands, and private land west of the Refuge in the lower Alatna River drainage that had not been included in past surveys. In all, this Total Survey Area consisted of 701 units.

Moose GSPE surveys have two components: stratification and intensive surveys. When funds are available, stratification flights are conducted before intensive flights to assign sample units to "High" (more than 3 moose) or "Low" (3 moose or less) moose density stratum. A good stratification survey improves the precision of population estimates by reducing the variance of the estimate. In 2011 and 2013 we did not have sufficient funds to conduct stratification flights, so the 2010 stratification was used (Craig and Stout 2011).

Sample units for the survey were randomly selected from each density strata (Kellie and DeLong 2006). Approximately 10 – 20% of the units were withheld from the random selection and subjectively used to fill in between blocks of units because the GSPE has a spatial component whose results are improved if there are no gaps among surveyed units.

For the intensive survey, tandem-seated aircraft (e.g., Super Cub and Scout) were used to survey individual units for moose. These aircraft held a backseat observer who also recorded data, and a pilot/observer who used a Global Positioning System (GPS) receiver to identify the boundaries of sample units and keep track of portions of units already surveyed. Search intensity varied with habitat. Greater effort was spent in areas with higher canopy cover (e.g., forests versus muskeg) or where fresh moose tracks indicated the potential presence of moose. Latitude/longitude coordinates of lone or grouped moose were recorded using the aircraft GPS receivers or hand-held GPS units operated by the back-seat observer. Each moose observed was classified as: cow, calf, yearling bull (spike or forked antlers), medium bull (a bull with antlers that were larger than spike or fork but whose antler spread was <50 inches [127 cm]), or large bull (antler spread $\geq$50 inches). Moose population estimates within the survey area were made using a web-based GSPE analysis program developed by ADF&G (Ver Hoef 2002, 2008; Kellie and DeLong 2006; www.winfonet.alaska.gov).

The GSPE survey methodology assumes 100% sightability of moose. However, this assumption is not often met (Boertje, ADF&G, unpublished data). Because not all of the moose in the survey areas were likely spotted during our survey, results presented herein are considered "observable" moose

RESULTS

Survey conditions

The survey was conducted 12 - 18 November 2011. All intensive survey pilots were experienced in survey techniques, as were all observers. Snow conditions during the survey period were good with complete snow cover of ground vegetation and temperatures were generally well above 0˚F (+ 18˚C). Survey conditions were classified as being "excellent" (37%) to "good" (48%) except for a few units where conditions were "fair" (2%) or they were not rated (12%). These ratings indicated that the survey conditions in 2013 were not as favorable as in 2011 when more units were rated as being excellent (52%) (Craig and Stout 2012). The "good" and "fair" classifications in 2013 were due to windy conditions, and/or relatively poor light condition (flat light, medium to low intensity light). Moving "scud", patches of ground fog, wind, and snow storms caused several delays and changes in survey strategies which lead to survey inefficiencies, including one day when planes were grounded.

Stratification Results

Of the moose we observed during intensive surveys, 84% (243) and 90% (232) were located in the units designated as High density SUs in the Total Survey Area, and the Refuge Survey Area, respectively. Further, the mean number of moose observed in High density SUs during the surveys was almost 9 times the number of moose detected in Low Density strata (Table 1). These data indicate that using the 2010 stratification classifications was justified for the 2013 survey, as well.

Table 1. Moose survey unit (SU) classification by density and habitat quality determined in 2010, and number of moose observed in each during a survey in November, 2013 in the Total Survey Area, Game Management Unit 24B, Alaska.

Survey area	*# High moose density SUs (% of area)*	*# Low moose density SUs (% of area)*	*#High moose habitat SUs (% of area)*	*# Low moose habitat SUs (% of area)*	*Mean # moose observed/ High density SUs 2013*	*Mean # moose observed/ Low density SUs 2013*
Total Survey Area	*75 (11)*	*626 (89)*	*375 (54)*	*326 (46)*	*3.2 (SE=4.8)*	*0.07 (SE=1.5)*

Population survey results

Of the 508 sample units within the Refuge Surveyed Area, 105 (21%) were surveyed for moose. A total of 66 High density units (63%) and 39 Low density units (37%) were intensively surveyed. Of the 701 sample units within the Total Survey Area (Figure 2), 129 (18%) were surveyed for moose. A total of 74 High density units (57%) and 55

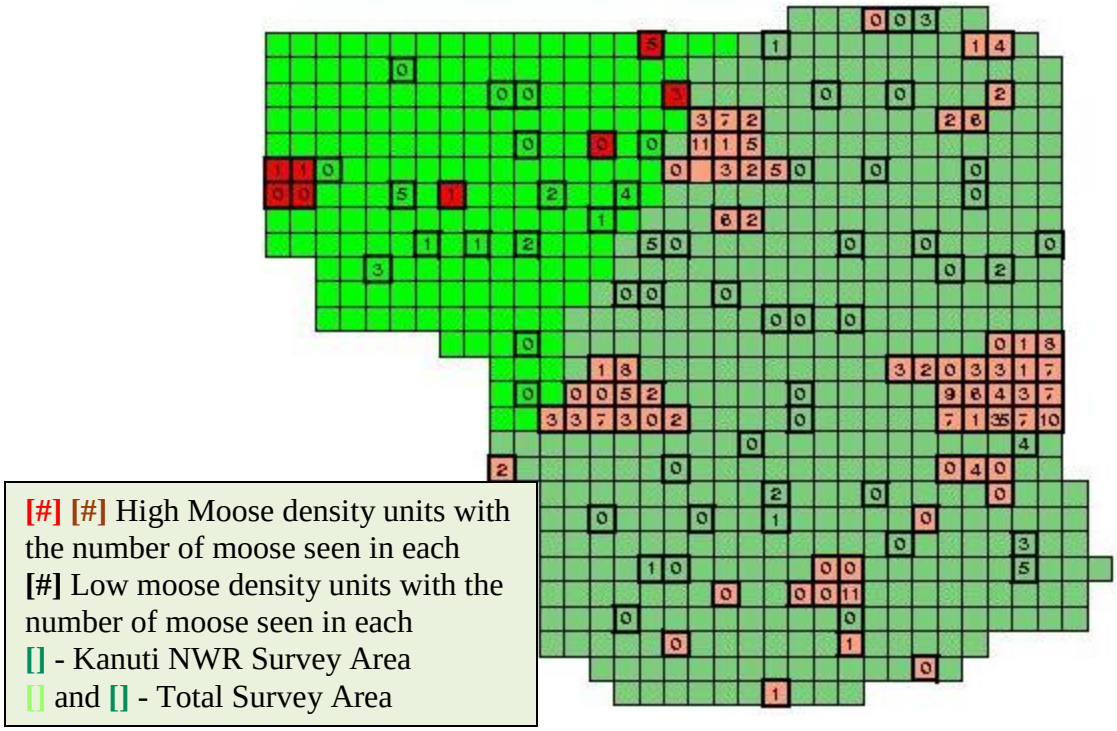


Figure 2. Moose counted in survey units in November, 2013 relative to moose density stratum. Kanuti NWR, and Total Survey Area, Game Management Unit 24B, Alaska.

Low density units (43%) were surveyed in this area. Survey time per unit ranged from 15 – 40 minutes with a mean of 27.2 (±5.1 SE) min. spent in survey units. The number of survey planes used ranged from 1 – 4 airplanes per day. The maximum number of units surveyed by any one plane during a single full day's attempt (omitting two planes which flew a few units on their arrival day) was 11 (mean = 7; R = 3 – 11). Variation in the number of units surveyed depended on their distance from Bettles, light conditions, fuel needs, number of moose in a unit, local weather, and habitat cover type (e.g. units with closed tree canopy required more time to survey).

Observers classified 259 observable moose within the 105 units surveyed in the Refuge Survey Area and counted a range of 0 – 35 moose in single units. This yielded an average count of about 2.5 moose per surveyed unit. Of these moose, 130 cows, 95 bulls, and 34 calves were classified. In the Total Survey Area, which included the Refuge Survey Area and the western additions, 289 moose were classified, including 145 cows, 105 bulls, and 39 calves. Three sets of twins were counted in the Total Survey Area and, as in 2011, all were located in units that were in the Refuge Survey Area.

The GSPE population estimate for the Refuge Survey Area was 551 moose (90% confidence interval = 410 - 693) which yields a density of 0.20 moose/mi^2 (0.08 moose/km^2) (Table 2). The Total Survey Area population estimate is 768 moose (90% confidence interval = 589 – 947) for a density of 0.21 moose/mi^2 (0.08 moose/km^2).

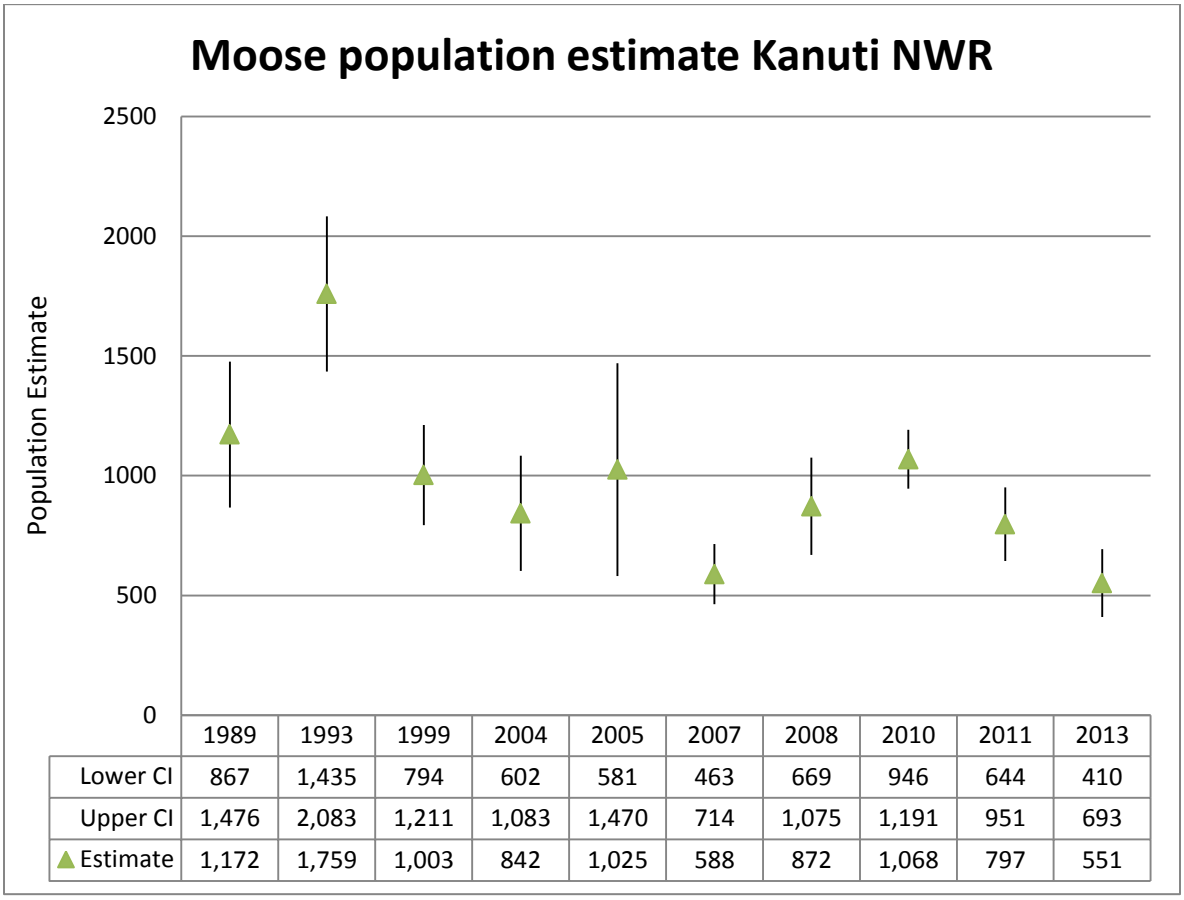
Table 2. Summary Statistics for 10 moose population estimates (90% Confidence Interval), in the Kanuti NWR Survey Area, Game Management Unit 24B, Alaska. Surveys conducted in 1989 and 1993 employed the Gasaway method while subsequent surveys were conducted using the GeoSpatial Population Estimator method.

	1989	*1993*	*1999*	*2004*	*2005*	*2007*	*2008*	*2010*	*2011*	*2013*
Survey Area (sq. miles)[1]	2,615	2,644	2,715	2,710	2,710	2,714	2,715	2,714	2,714	2,714
Units Surveyed	NA[2]	NA[2]	108	103	82	150	80	164	151	105
Population Estimate (Range of Estimate)	1,172 (867 - 1,476)	1,759 (1,435 - 2,083)	1,003 (794 – 1,211)	842 (602 – 1,083)	1,025 (581 – 1,470)	588 (463- 714)	872 (669 – 1,075)	1,068 (946- 1,191)	797 (644- 951)	551 (410 - 693)
Standard Error	NA	NA	127	146	270	76	124	74.5	93	86
Moose Density (moose/sq. mi)	0.45	0.67	0.37	0.31	0.38	0.22	0.32	0.39	0.29	0.20
Estimated Cows	NA	NA	542	403	471	276	432	569	388	283
Estimated Bulls	NA	NA	320	252	331	167	199	293	268	183
Bulls:100 Cows	64	61	59	62	70	60	46	51	69	65
Yearling Bulls:100 Cows	4	8	4	9	20	13	14	7	10	11
Calves:100 Cows	17	33	30	46	43	53	58	33	41	36

[1] Survey areas vary among years depending on how survey units were delineated

[2] Not Available. Survey units varied in shape and size and are not comparable to units used in subsequent surveys

The relatively narrow 90% confidence interval (it is standard practice to compare 90% CI among GSPE surveys in Alaska) for the 2013 population estimate confirms that this is among the top three most precise estimates of the moose population on the Refuge Survey Area (Figure 3). We plotted the 90% confidence error of the estimated total number of observable moose against the corresponding number of sample units for all GSPE surveys completed on the Kanuti NWR. We determined that a sampling intensity of 125-145 sample units is needed to achieve a 90% CI of 15-20% of the total estimate (Figure 4).



	1989	1993	1999	2004	2005	2007	2008	2010	2011	2013
Lower CI	867	1,435	794	602	581	463	669	946	644	410
Upper CI	1,476	2,083	1,211	1,083	1,470	714	1,075	1,191	951	693
▲ Estimate	1,172	1,759	1,003	842	1,025	588	872	1,068	797	551

Figure 3. Observable moose population estimates by year on Kanuti NWR, Game Management Unit 24B, Alaska. Error bars represent the 90% confidence interval for each year.

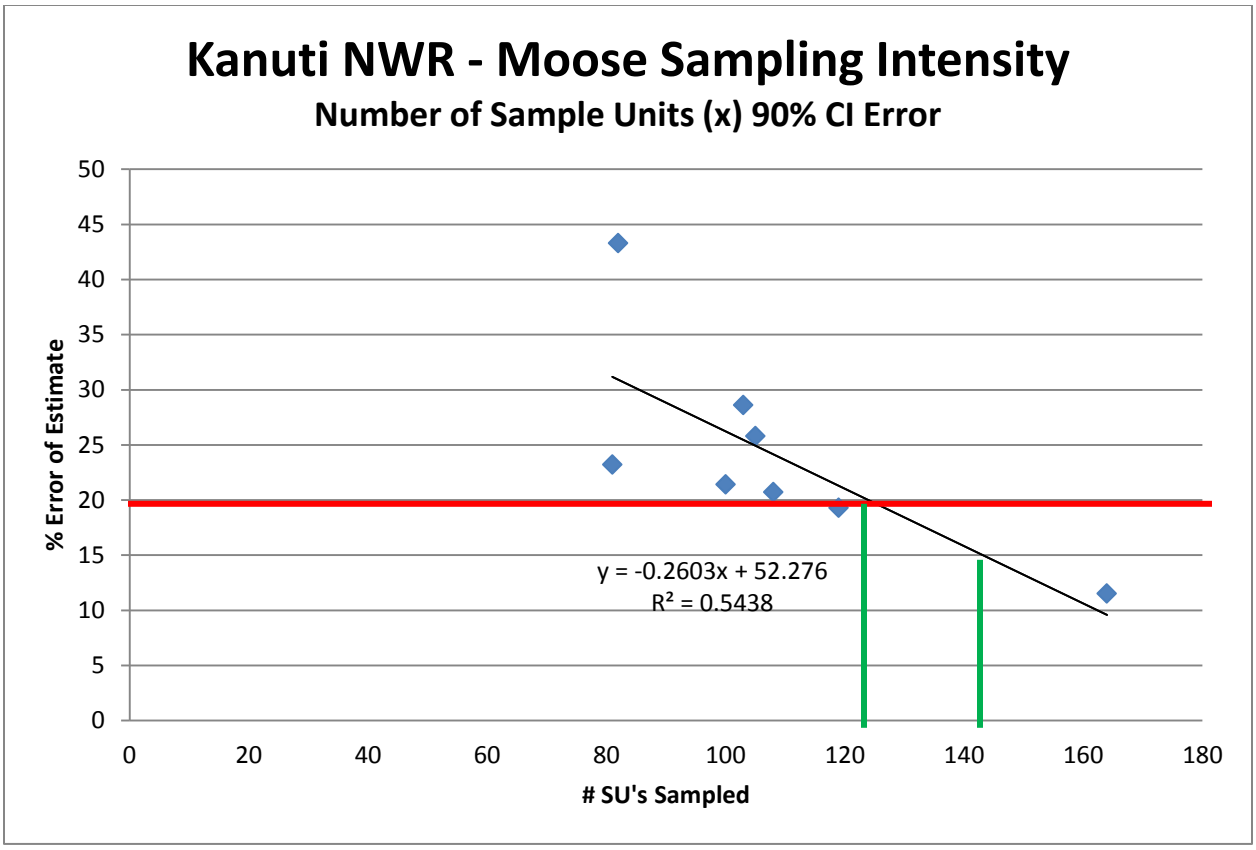


Figure 4. Number of sample units surveyed and the percent error of the estimated total number of moose from eight GSPE moose surveys conducted from 1999 to 2013, on Kanuti NWR, Game Management Unit 24B, Alaska. The red line represents a potential threshold sampling objective, the green lines represent a range of the number of sample units needed to achieve the sampling objective threshold of 15-20% sampling error, and the black line is a linear regression of the eight data points.

Estimated moose densities by sex and age class in the Refuge Survey area were 0.07 bulls/mi^2, 0.10 cows/mi^2, and 0.04 calves/mi^2 (03.0/km^2, 0.04/km^2, and 0.02/km^2, respectively). Population estimates and ratios (indexed to 100 cows) for bulls by age class for the Total Survey Area are presented in Table 3.

Table 3. Estimated bull moose population and age ratios in November, 2013 indexed to 100 cows in the Kanuti NWR and Total Survey Area, Game Management Unit 24B, Alaska.

	All bulls	Yearling bulls[b]	Large bulls
Population estimate			
Kanuti NWR Survey Area	183	31	104
Total Survey Area	257	44	156
Ratio estimate: 100 cows			
Kanuti NWR Survey Area	65:100	11:100	37:100
Total Survey Area	67:100	11:100	40:100
90%CI[a]			
Kanuti NWR Survey Area	117 - 250	11 - 52	49 - 158
Total Survey Area	173 - 342	18 - 70	85 - 228

[a] Upper and lower estimate of confidence intervals (CI).
[b] Assuming a 50:50 sex ratio for yearlings, total yearling density in the survey area is expected to be twice that of yearling bulls

Costs by agency for the 2013 GSPE survey are found in Appendix 1. Complete survey results for the entire 2013 survey are archived in, and can be retrieved from, the Alaska Department of Fish and Game's WINFONET database (http://winfonet.alaska.gov/; accessed 25 January 2011). An example of output from WINFONET is found in Appendix 2.

DISCUSSION

The Refuge Survey Area was surveyed eight times using GSPE techniques since 1999. Even though we used stratification data from 2010, and we had poorer survey conditions than in the recent past, the data collected in 2013 resulted in the third most precise (tight CIs) of these moose surveys. This probably resulted for two reasons. First, the precision of a population estimate of a subset of SUs is improved in the geospatial analysis by surveying a contiguous, larger area. Therefore, surveying units in the Total Survey Area improved the precision of the estimates in the smaller Refuge Survey Area. Secondly, all of the pilots and observers who participated in the 2013 survey had experience with the GSPE survey method.

We determined that at least 125 sample units should be surveyed to achieve a survey with less than a 20% spread in confidence intervals for a single-year "point estimate" of the Refuge moose population (Craig and Stout 2012). However, our alternative "low-intensity" sampling strategy of 80-100 sample units (we sampled 105 units on the Refuge in 2013) provides the desired results for management purposes with nearly the same precision threshold (20%). Moreover, low-intensity surveys conducted on a regular basis, with periodic high-intensity surveys, produce estimates that allow a precise analysis of trend (Craig and Stout 2012). Low-intensity surveys are affordable and are more likely to be conducted frequently, which enables managers to monitor population trend. Further assessment of this sampling strategy will be evaluated using future survey data, to

determine the sampling intensity and frequency required to detect small population changes (5-10%) for this low density population.

Moose population density estimates determined for the Refuge Survey Area over the years have ranged from 0.20 to 0.39 moose/mi^2. The confidence intervals overlap for the population estimates for all but one (2010) of these surveys. The results for 2013 were the lowest we have recorded on the Refuge, but the population trend is consistent with a low-density dynamic equilibrium moose population described by Gasaway et al. (1992). In 2013 we observed 283 cows, well below that expected based on the results from the 7 previous surveys ($\overline{X}$ 440±37.5 SE cows; 90% CI = 367 – 513) and 27% below the 2011 estimate. An actual decline of that magnitude in just 2 years is unlikely, suggesting that survey conditions are responsible for the perceived difference. The 2013 survey conditions were comparable to 2007 when SU conditions were 27% excellent, 58% good, 9% fair or poor and 5% unrecorded. The results from the two surveys were also very similar. It is most likely that the results we obtained in 2013 were related more to less favorable survey conditions than actual changes in demographics. Nonetheless, we recommend that the survey be repeated again in 2014 in order to determine if this apparent downward trend is real, or a sampling artifact. Additionally, because it will have been 4 years since a high-intensity survey was conducted, we recommend a the 2014 survey use a sampling intensity of at least 145 SU's and that a new stratification survey be conducted in order to achieve an error rate of 15% or less.

The 2013 data indicate that while moose numbers probably do fluctuate somewhat in the survey area, the moose density continued to remain consistently low over the past decade. This is typical for Interior Alaska moose populations where hunting and trapping pressure on predators is low. Gasaway et al. (1992) report a mean density of 0.38 moose/mi^2 (0.15 moose/km^2) for 20 moose populations in Alaska and the Yukon Territory where predation was thought to be a limiting factor. Where predation was not thought to be limiting, the mean density of 16 populations was 1.7 moose/mi^2 (0.66 moose/km^2). The current estimated moose density of observable moose on KNWR Survey Area is 0.20 moose/mi^2 while the average over the years when GSPE methods were used is 0.31 moose/mi^2 (±0.06).

The Refuge Survey Area moose population maintained a relatively high bull/cow ratio (46 – 70 bulls/100 cows) over the years, and the 2013 data remain consistent (65 bulls/100 cows). This probably is a result of the low human harvest on the Refuge due to past management strategies. A minimum of 20 bulls:100 cows in the fall is considered adequate to maintain moose numbers, except in low density areas like the Refuge, where moose are more widely dispersed. In this low density population, a ratio of 30 – 40 bulls:100 cows (ADF&G 2001) may be required to maintain the population.

Calf ratios of 20 - 30 calves:100 cows are suggested necessary to maintain a stable moose population; ratios exceeding that are needed for moose populations to grow (ADF&G 2001). In the 2011 GSPE survey, we estimate there were 41 calves/100 cows on the Refuge and in 2013, 36 calves/100 cows. In fact, the estimated calf:cow ratios in 5 of the 8 GSPE surveys conducted in the past have exceeded 40 calves/100 cows. These fall

calf:cow ratios indicate the moose population on the Refuge Survey Area has adequate productivity to grow. However, we have detected no commensurate increase in moose density in the study area in the past decade, suggesting that recruitment of yearlings or survival of adults is lower than predicted.

It is clear that recruitment is below potential for this population when considering the high twinning rates we have observed (Craig and Stout 2012), and the relatively low number of calves and yearling bulls in November surveys. Within the Koyukuk River drainage, downstream from the Refuge, Osborne et al. (1991) found that black bears (*Ursus americanus*) were responsible for 40% of the calf (< 6 mo. old) mortalities, while brown bears (*Ursus arctos*) (3%) and wolves (*Canis lupus*) (9%) accounted for far fewer mortalities. Bertram and Vivion (2002) found that even though moose on the nearby Yukon Flats National Wildlife Refuge had high pregnancy and twinning rates, predation by black bears (45%), and grizzly bears (39%) were responsible for low (28%) neonate survival. Others report that predation by bears and wolves can limit growth in low-density moose populations that are lightly hunted in Alaska and the Yukon (Gasaway et al. 1992). It is probable that the mortality of subadult moose revealed in our survey data is also due to predation by bears and wolves.

Moose habitat quality in Interior Alaska is often related to ecological succession in areas that have burned and subsequently change through time. The Refuge Survey Area is largely a fire-dominated ecosystem and has experienced several large fires since 1990. Research elsewhere in Interior Alaska indicated that burns between 10 – 30 years old are preferred over younger burns by moose (Maier et al. 2005). This is supported by observations on the Refuge during the 2013 survey and in past moose surveys, as well. Many of the High moose density units in both the Total Survey Area and the Refuge Survey Area were in burns that were more than 10, but fewer than 30 years old. One exception is a hilly, older burn about 20 km south of Allakaket where the terrain, with its varied microsites, apparently still hosts habitat attractive to moose. Climate change models predict an increased incidence of fire in Interior Alaska (Rupp 2009) concurrent with a drying trend (SNAP 2009). It is difficult to predict how these changes will affect moose habitat in the survey area in the future.

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APPENDIX 1

Moose Survey Costs by Agency, November 2013

Kanuti National Wildlife Refuge

Vendor	Description	Flight hours	Cost ($)
Sam's Club	Food		211
Fred Meyers	Food		90
Safeway	Food		68
Sam's	Food		285
Wright's	Freight		192
OASt	Scout	28.4	5,680
Holiday worked	MS		806
Holiday worked	TC		535
Total			7,868

Bureau of Land Management

Vendor	Description	Costs ($)
Brooks Range Aviation	Fuel	3,000
Warbelow's	Airfare/travel	883
Total		3,883

Alaska Department of Fish and Game

Vendor	Description	Costs ($)
Fred Meyers	Food	195
Wrights	Travel/freight	730
Bettles Lodge	Fuel	520
Tundra Air (Marty Webb)	Air charter	3,293
Papa Zulu Air (Paul Zaczkowski)	Air charter	5,134
Shadow Aviation (Andy Greenblatt)	Air charter	6,550
Total		16,422

APPENDIX 2

WinfoNet

Moose Surveys - Population/Ratio Estimates

Do A Population Estimate | Do Another Ratio

Moose Population Ratio Estimate--Geo Technique

Survey: 24B KANUTI
Year: 2013
Season: Fall

REQUEST PARAMETERS	
Numerator Column:	[LG_BULL]
Denominator Column:	[TotalCows]
Analysis Area:	InTotSurvey
Strata Column:	StratName
Counted Column:	Counted
Unit Area Column:	AreaMi

Right click to download data used to calculate estimate.
Right click to download RCode used to calculate estimate.

RESULTS

Ratio Estimate	
Ratio Estimate:	0.4054146
Standard Error:	0.1278298
Covariance:	230.2747

Confidence Intervals		
Confidence	Interval (moose)	Interval (proportion of the mean)
80%	0.2415941 0.5692350	0.4040813
90%	0.1951533 0.6156758	0.5186327
95%	0.1548728 0.6559563	0.617989

Numerator Estimate	
Numerator Estimate:	156.3812
Standard Error:	43.41574

Confidence Intervals		
Confidence	Interval (moose)	Interval (proportion of the mean)
80%	100.7417 212.0207	0.3557942
90%	84.96863 227.79372	0.4566569
95%	71.28788 241.47447	0.5441403

Denominator Estimate	
Denominator Estimate:	385.7315
Standard Error:	66.78379

Confidence Intervals		
Confidence	Interval (moose)	Interval (proportion of the mean)
80%	300.1446 471.3184	0.2218820
90%	275.8820 495.5811	0.2847824
95%	254.8377 516.6253	0.3393392

SAMPLE DETAILS

Total Samples

```
  stratum sample.sizes
1     HIGH          75
2      LOW         626
3    TOTAL         701
```

Total Area

```
  stratum total.area
1     HIGH    399.957
2      LOW   3335.676
3    TOTAL   3735.633
```

Numerator Counted

```
  stratum counted
1     HIGH       34
2      LOW       10
```

Sample Sizes

```
  stratum sample.sizes
1     HIGH          74
2      LOW          55
3    TOTAL         129
```

Area Sampled

```
  stratum sampled.area
1     HIGH      394.672
2      LOW      292.729
3    TOTAL      687.401
```

Denominator Counted

```
  stratum counted
1     HIGH      122
2      LOW       23
```

ESTIMATE DETAILS

Numerator

Stratum	Name 1 HIGH	Name 1 LOW
Empirical Semi-Variogram	distance gamma np 1 4.364015 0.02726671 242 2 9.467177 0.03526352 422 3 15.590772 0.03038085 266 4 21.507244 0.04314247 162 5 28.283036 0.01306805 122 6 35.012958 0.01977028 354 7 40.871001 0.01695539 510 8 46.889370 0.02272119 632	distance gamma np 1 3.959305 0.010150006 24 2 9.946873 0.007024603 126 3 15.883422 0.006163967 172 4 22.101969 0.006484226 224 5 28.177981 0.008120117 226 6 34.232910 0.006463655 286 7 40.580204 0.008527141 306 8 47.064487 0.006982147 286
Parameter Estimates	2.620636e-02 3.155887e-11 2.547812e+01	0.009412082 0.001552055 26.388859191